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Fostering Collaboration Through API Economy: The E015 Digital Ecosystem

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ABSTRACT

The API Economy trend is nowadays a concrete opportunity to go beyond the traditional development of vertical ICT solutions and to unlock additional business value by enabling innovative collaboration patterns between different players, e.g., companies, public authorities and researchers. Thus, an effective API Economy initiative has to be comprehensive, focusing not only on technical issues but also on other complementary dimensions.

This paper illustrates a successful API Economy initiative, the E015 Digital Ecosystem developed for Expo Milano 2015, showing how a comprehensive approach to information systems interoperability and Service-Oriented Architectures can foster synergetic collaboration between industry and academia in particular, hence enabling the development of value-added solutions for the end-users.

CCS Concepts

• Software and its engineering~Interoperability • Software and its engineering~Reusability • Software and its engineering~Collaboration in software development • *Information systems~Web services* • Computer systems organization~Distributed architectures

Keywords

Digital Ecosystems; APIs; API Economy; Application Mashup; Interoperability; Standards and Guidelines; Web Services; Digital Assets; ICT Governance; Service-Oriented Architectures; Collaboration Mechanisms; E015; Expo Milano 2015.

1. INTRODUCTION

The development of software solutions is still one of the most relevant ICT trends of the recent years. Nowadays almost every business sector or aspect of our daily life requires the interaction with devices running software solutions targeted to the end-users, enabling easy access to tailored functionalities and huge amounts of data meeting users' needs.

Unfortunately, in many cases this trend can lead to the development of replicated software solutions, each one structured as a monolithic "silo" (*vertical application*) with its own database, business logic and graphical user interface.

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Monolithic software solutions are also very common within complex and widespread enterprises or public authorities. In this case, the lack of cross-organizational coordination as well as the absence of a global and coherent reference architecture for the governance of all the available digital assets often result in massive replication of data and ICT functionalities across different business and organizational units, fragmented end-user applications and limited software interoperability.

In recent years, some companies and public authorities have started to adopt *APIs* (*Application Programming Interfaces*) [8] as a technological enabler for interoperability between different monolithic solutions. Leveraging the capabilities of APIs, data and functionalities provided by vertical solutions can be "unlocked" and shared horizontally across different business and organizational units, thus enabling the creation of integrated applications providing also functionalities deriving from other information systems. Such applications realize the so called *application mashup* and provide a richer and more immersive experience to the end-users. Figure 1 illustrates how, according to this new paradigm, APIs can be derived from existing vertical solutions (e.g., data layer, business logic layer) and reused by other solutions.

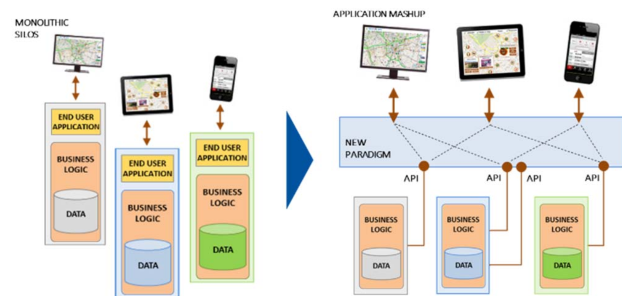


Figure 1. From monolithic ICT solutions to APIs and application mashup

Moreover, some companies and public authorities have started to share their internal ICT business assets in the form of APIs [2] not only across internal organizational units, but also to external third parties, with the goal of unlocking additional business value through the creation of new asset classes. This trend is nowadays widely referred to as *API Economy* [2]. In the API Economy scenario, APIs can be considered as the "wholesale" version of a Web presence, allowing other parties to access and integrate company's data and resources into their public or private sites and applications. This trend determines a disruptive change in the traditional paradigm of ICT applications development, since it mainly focuses on the availability of digital assets (the *back-end* layer) in order to allow third parties to develop value-added applications for the end-users (the *front-end* layer).

The API Economy not only is an opportunity for public and private companies to go beyond the traditional development of vertical solutions, but also represents the foundation to enhance collaboration between research and industry. In particular, this innovative form of collaboration can take place at two different levels of engagement:

1. On the one hand, researchers and the Software Engineering community in particular can leverage the power of APIs in order to share their latest achievements (e.g., algorithms, data processing capabilities) with other parties.

2. On the other hand, domain specific practitioners can combine these innovative APIs with their digital assets in order to discover new scenarios and forms of exploitation of research achievements at an application level, thus putting Service-Oriented Application principles into practice.

This paper has the ambition to show how the API Economy can represent an effective chance to foster collaboration between researchers and practitioners according to the two levels of engagement mentioned above. To pursue this goal, the paper illustrates some key characteristics of the *E015 Digital Ecosystem* [12], the environment of APIs and applications developed for the Universal Exposition of Expo Milano 2015, nowadays recognized as a best practice and a successful reference initiative in the field of the API Economy.

The paper is organized as follows:

- Section 2 summarizes the main obstacles and needs that have to be addressed for a broader adoption of the API Economy as a reference collaboration paradigm between the Software Engineering community and practitioners.

- Section 3 introduces the E015 Digital Ecosystem, describes its reference model, provides some examples of real scenarios empowered by this initiative, and explains how the problems and needs introduced in Section 2 have been addressed.

- Section 4 highlights how E015 contributes to bridge the gap between researchers and practitioners, and depicts the new collaboration scenarios empowered by the API Economy at different levels.

- Section 5 presents some conclusions and closing remarks.

2. GAP BETWEEN RESEARCHERS AND PRACTITIONERS IN THE API ECONOMY ARENA

The API Economy represents an opportunity to unlock additional value from available digital assets and to go beyond the development of monolithic ICT solutions. This trend fosters collaboration among different actors (e.g., internal business units, external partners, private companies, public authorities) and enables the creation of integrated applications providing an immersive and coherent experience to the end-users.

Year after year, Software Engineering has provided the necessary foundations and technological achievements to enable an effective adoption of APIs in the development of ICT solutions:

- Open technological standards for communication and interoperability between software components (e.g., HTTP protocol, SOAP protocol, XML).

- Open technological standards to manage digital identity (e.g., SAML) and to guarantee security of interaction (e.g., SSL/TLS).

- Reference architectural patterns and advanced techniques for the design and development of distributed systems (e.g., Service-Oriented Architectures).

- Multiple interaction paradigms to enable different scenarios of cooperation among software components (e.g., request-response paradigm, push notifications).

- Processes, techniques and tools to manage the entire software lifecycle.

- Machine learning and cognitive computing for the development of autonomous systems.

- Data mining and semantic Web approaches to enhance data integration and to extract additional value from existing data sources, both structured and not structured.

These are some examples of fundamental results stemming from research that allowed APIs to become an effective and mature technological approach for the development of complex and widespread information systems. In addition, today the majority of available tools and platforms provided by ICT providers and open source community initiatives guarantee high compatibility with these standards, making it easier for developers to build interoperable solutions adopting the API approach.

Unfortunately, despite the incremental consolidation and dissemination of these standards and technologies, the overall level of adoption of the API Economy is still limited and this trend has not yet expressed its full potential.

Indeed, even if on the one hand APIs are widely adopted by international companies providing ICT services (e.g., Google, Amazon, Apple), large software platforms vendors (e.g., IBM, Oracle, Microsoft) and innovative startups, on the other hand more traditional industries, local software houses and vendors, SMEs and many public authorities still have to fully understand the potential of the API Economy.

As a result, many public and private players persist with the development of fragmented, isolated and unable to cooperate application silos. The so called *API-first* approach in software development has not been widely embraced yet and APIs are not considered as stand-alone ICT products to be designed, developed and offered (through service interfaces) the same way it happens with end-user applications.

This situation implies some negative consequences:

- *Limited end-users' digital experience*. Because of the presence of many isolated applications, the end-users themselves have to perform data and process integration by using many different applications, each one covering only a piece of the overall set of requirements and needs.

- *Scarce reuse of available digital assets and functionalities*. The silo approach relies on a strong coupling among different application layers. Digital assets are not designed as stand-alone products potentially exploitable by external consumers through software interfaces. For this reason, an ICT solution cannot immediately cooperate with other ICT solutions in order to reuse the same digital assets.

- *Higher costs and more uncertainty in performing time estimates for software development*. Since application silos do not share digital assets through APIs, cooperation with other ICT solutions is achieved through ad-hoc, replicated and not scalable system integration activities. Moreover, data and functionalities are often replicated across different applications and channels, making it difficult to guarantee data alignment and overall coherence to the end-users.

- *Lower flexibility in response to changing requirements*. Since vertical solutions do not extensively rely on modular components like APIs, changes in functional requirements may determine deep impacts across the whole software architecture. Consequently, functional requirements and actual solution behavior may not be properly aligned.

- *Infeasibility of effective business process reengineering and optimization*. In many cases, vertical solutions are the direct digitalization of specific business processes. I.e., these solutions simply translate certain process phases and activities within a monolithic software implementation. Such an approach represents a serious obstacle each time a true process reengineering or optimization is needed.

Therefore, even if APIs represent a major trend in software development and interoperability technologies are mature and extensively supported by ICT platforms, the adoption of APIs as a means of collaboration is still limited and difficulties persist in transferring this opportunity both to private and public players.

This situation is mainly due to the fact that the API Economy has been mainly tackled from a mere technological standpoint. Technology does certainly play a key role in enabling the API Economy, e.g., interoperability standards represent a necessary layer for sustaining the creation of ICT solutions for asset sharing between different players. However, technology is just one of the fundamental dimensions underlying the API Economy phenomenon. Other complementary dimensions should be taken into account that help facing challenges such as: understanding APIs and the additional value they unlock, sharing both business and operational knowledge about APIs, exploiting APIs effectively and efficiently for building solutions ready for the market. Instead of focusing only on interoperability standards and technologies, in fact, we should investigate what is really needed at application level in order to enable players to proficiently use and in turn create APIs.

Therefore, some of the crucial characteristics that must be taken into account when developing API Economy initiatives to foster collaboration among multiple actors are:

Organizational roles and processes. Each API Economy initiative should define specific roles in order to guarantee and support overall coherence, strategic evolution and day-by-day management. These roles must take into account at least the following aspects:

- *Strategical governance*. E.g., define the overall objectives and vision, promote the involvement of strategical partners, promote the dissemination of the initiative, create consensus among multiple players, monitor business KPIs, guarantee long-term evolution.

- *Technical governance*. E.g., define the overall technical architecture, identify or define the interoperability standards, verify the compliance with technical and process requirements, monitor technical KPIs, guarantee technical evolution according to both ongoing trends and achievements coming from research.

- *Possible roles covered by involved partners*. E.g., definition of how the different players can take part in the initiative.

It is also necessary to define the reference processes according to which participants can interact and cooperate, e.g., processes to publish new APIs, processes to obtain access to APIs provided by other parties, processes to publish new solutions.

Technical reference architecture, standards and guidelines. From a technical viewpoint, it is necessary to define the overall technical architecture specifying how digital assets (e.g., APIs) can be shared and accessed by other parties. Essential characteristics of this reference architecture should be:

- *Infrastructural components* enabling the interaction between participants through APIs and the monitoring of the initiative.

- *Interoperability standards* all participants should adopt in order to share APIs with other parties. These standards should not be proprietary, instead they should be selected from open specifications coming from research.

- *Technical guidelines* covering rules and best practices about how interoperability standard should be used in order to both share and consume APIs.

- *Domain specific standards* for the standardization of semantics of data and information that belong to specific domains (e.g., tourism, transportation, health care, education).

Onboarding initiatives. Any API Economy initiative should include onboarding and dissemination activities in order to promote participation and adoption. These initiatives must be both technology-oriented (e.g., technical sessions about standards and guidelines, hackathons) and, more importantly, business-oriented (e.g., roadshows, creative bootcamps, co-design initiatives). Moreover, onboarding actions are also very important in order to create consensus and promote a "cultural shift" towards the adoption of new technologies and approaches for the development of ICT solutions in line with the API Economy paradigm.

Policies and business models. An API Economy initiative should also define clearly the business rules according to which the participants can join the initiative and create relationships. E.g., an API Economy initiative could be restricted only to certain players (e.g., companies belonging to a specific business sector), or it can support only specific interaction models (e.g., 1-to-N model where a single API provider offers its APIs to multiple consumers, or N-to-M model where many API providers can interact with many API consumers). Moreover, it is necessary to define the business model of the overall initiative, as well as how participants can specify their own terms of use and business models about the digital assets they share.

The E015 Digital Ecosystem initiative addresses from the outset not only the technology related challenges (e.g., selecting – not inventing – shared standards and specifications for building APIs and ecosystem components) but also the other complementary dimensions mentioned above. For each dimension, the E015 model proposes an approach that fosters a concrete adoption of the API Economy in real scenarios involving both private and public players according to the N-to-M interaction model.

3. THE E015 DIGITAL ECOSYSTEM CASE STUDY

3.1 Overview

E015 [12] is a digital service-based ecosystem operating in Italy since 2013. It was initially developed in order to exploit the Expo Milano 2015 [7] as a major opportunity to introduce disruptive innovation in providing visitors and citizens with a novel and immersive experience, as well as in all aspects of urban daily life: infrastructures, transportation, cultural and social life, accommodation, services and facilities etc.

E015 enables a new approach to the design and implementation of advanced digital services. The ecosystem provides members (e.g., companies, public authorities) with participation guidelines and a set of shared and consolidated standards, processes, policies and technologies to develop their digital products (i.e., APIs, end-user applications) and enable information systems interoperability.

E015 exploits the notion of API economy which provides full, bidirectional and direct interoperability among autonomous distributed applications that access and exploit shared digital services. The interoperability model is based on open standards: Web Service interoperability specifications, security standards etc.

E015 is now one of the legacies that Expo Milano 2015 leaves to the city, to Lombardy and more generally to the European public and private system after the closure of the event.

3.2 Background

The E015 project was established in 2010 by major Italian associations of industries and companies (Confindustria, the Chamber of Commerce of Milan, Confcommercio, Assolombarda and Unione del Commercio). The E015 reference model was conceived by CEFRIEL, since then in charge of the scientific coordination and evolution of the ecosystem. The E015 interoperability standards, technical guidelines and overall architecture were defined with the important contribution of a Scientific Technical Committee from academia. In 2011, the public utility Expo 2015 S.p.A. became a full partner of the initiative and the operator of the ecosystem technical infrastructure.

As the result of the convergent efforts of a number of different actors and partners operating in the Milan Urban Area, pilot initiatives to test E015 were started by six large companies, i.e., the major national and regional transportation players (SEA, ATM, Trenitalia, Trenord, Milano Serravalle – Milano Tangenziali, Infoblu – Autostrade per l'Italia).

In accordance with an iterative approach, this initiative led to the publication in the ecosystem of a number of real-time services focused on the Milan Urban Area mobility domain: traffic information and camera views on main streets, highways and bypasses; status and timetables of railway services, public transportation and flights in Malpensa and Linate airports; status and availability of car parking slots and bike sharing stations. Such APIs were then leveraged by different end-user applications made available as mobile apps, Web sites, information kiosks etc.

In 2013, the E015 Digital Ecosystem was publicly launched. Since then, hundreds of participants from both the public and the private sector (e.g., private companies from multiple business sectors, SMEs, public authorities, universities, innovative startups) signed the membership contract. Thanks to E015, 40 innovative applications (such as multimedia totems, Web sites, smartphone apps) were published during the Expo Milano 2015 and contributed to enrich the visitor experience of the event. Such applications used third-party APIs among the 100 available at that time through E015.

In October 2015, the Regional Government of Lombardy replaced Expo S.p.A. as the organization in charge of managing the E015 Digital Ecosystem in future years, and therefore E015 became one of the most important legacies of Expo Milano 2015. Today E015 is still very active, its community is constantly growing in terms of new participants, and more and more services and applications are being published in the ecosystem.

3.3 Reference Model

E015 is an open API ecosystem. Ecosystem participants can describe and publish their Web services (i.e., APIs), in terms of both functionalities and usage policies, in order to share their data assets through standard Web service interfaces. Other participants can then discover such services and leverage them, in agreement with the respective usage policies, for building new value-added services or new integrated applications for the end-users, thus contributing to the overall growth of the ecosystem. The interoperability model is based on open standards, thus enabling open innovation [3].

Figure 2 provides a high-level view of the E015 architectural reference model.

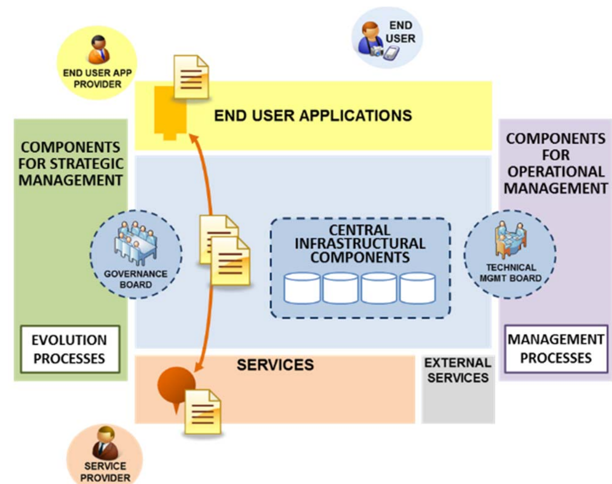


Figure 2. E015 architectural reference model

Everyone can join the ecosystem: membership is free and can be activated online through the E015 Web portal [4]. By signing and uploading the contract, members commit themselves to comply with the E015 public guidelines and technical standards.

E015 in fact provides members with guidelines for participating in the ecosystem – i.e., the E015 "common language" – for developing their software products and for interoperating with other members.

Members can contribute to the ecosystem in different ways. I.e., basically they can:

- *Publish E015 services*, i.e., expose part of their own information assets and functionalities in the ecosystem through Web services, so that other members can ask for usage and integrate them into applications for the end-users.
- *Build E015 end-user applications*, i.e., develop Web sites, mobile apps, information kiosks etc. providing end-users with value-added contents and functionalities built by integrating the data and functionalities provided in real-time by the E015 services.

- *Share E015 glossaries*, i.e., provide standard ways to represent information in the ecosystem by means of taxonomies, ontologies, classification schemes etc. so that members can rely on a set of shared and consolidated data models for developing their software products and for interoperating with other participants.

Moreover, E015 relies on the following internal roles:

- *Technical Management Board*. The team in charge of managing the technical and procedural aspects of the ecosystem, such as: maintain and evolve technical and process guidelines; manage the ecosystem registries, the Web portal and the other "core" components; provide technical and procedural support to ecosystem participants; validate services and applications in order to assess their compliance with E015 technical standards and guidelines; monitor the availability of services and, in general, the health of the ecosystem.
- *Governance Board*. The team in charge of long-term governance and strategic evolution of the ecosystem. They take care of different tasks, such as: management of membership requests; management of communication and relationships; strategic planning and management of long-term evolution of the E015 Digital Ecosystem.

3.4 Key Aspects and Benefits

The E015 Digital Ecosystem comprises a number of synergic elements that enable a novel relationship model between different entities:

- A *digital lightweight interoperability environment* based on the Service-Oriented Architecture paradigm and on open standards. E015 technical standards have been chosen with the support of a Scientific Technical Committee from academia, and validated with the contribution of Italian associations of industries and companies.
- A *flat, centralized technical infrastructure* enabling a peer-to-peer cooperation model, including, e.g., common registries where APIs, end-user applications and glossaries are listed and described, an automated API monitoring tool, and a Web environment to support interactions among participants according to E015 standard processes and rules.
- A set of *collaboration rules, policies and processes* ensuring non-discriminatory access to the ecosystem and fostering *coopetition* [1], i.e., "cooperative competition", consisting in promoting cooperation among different entities (e.g., individual developers, academia, companies and industries, public authorities) while not interfering with their own business models (e.g., development of services and solutions offered to the customers according to their own market approach). Every E015 member in fact has the faculty of proposing its own terms and conditions as for accessing their digital services shared through the ecosystem, thus enabling compatibility with any business model.
- A bespoke *API Descriptor*, including both technical aspects (e.g., interface description, data model description, supported interaction patterns, supported technologies, security requirements) and organizational aspects (e.g., name, business owner, logo, pricing plan, terms of use, time of availability, roadmap for evolution) that govern the usage of the API.
- A bespoke *Application Descriptor*, supporting Application Providers in planning and describing the intended use of the APIs they are requesting for building end-user applications.
- *Thematic glossaries* (e.g., shared data schemas, ontologies) developed by members (local associations and public authorities in particular) in order to promote standardization and interoperability in building and accessing digital services.
- A *Technical Management Board* supporting E015 members in validating and sharing APIs, end-user applications and glossaries, as well as in charge of updating the technical standards adopted in the ecosystem.
- A *Governance Board* that ensures neutrality of the ecosystem and takes care of promotion and diffusion of E015 across several domains and sectors of the society.
- Many *onboarding initiatives* promoted both by the Technical Management Board and by the Ecosystem founders in order to increase E015 adoption. E.g., technical sessions about E015 processes and guidelines; public events and roadshows about the overall initiative; "Welcome Meetings" with E015 new participants; business-oriented sessions and co-design initiatives with participants and prospects in order to explore how to exploit E015 potential; hackathons and bootcamps.

The E015 overall approach differs from traditional API marketplaces nowadays available on the Web (e.g., Mashape [10]). In fact, existing API marketplaces address the API Economy opportunity mainly from a technical viewpoint, by providing software developers with tools, platforms and technologies to implement and consume APIs (e.g., API gateway, API usage dashboards, API interface description tools). E015 goes beyond this approach and proposes a more comprehensive framework. By means of a lightweight architecture and guidelines, E015 targets both technical and business stakeholders, thus enabling at the same time technological standardization, process convergence, effective coopetition among parties, openness to multiple business models and long-term evolution in accordance with a reference vision.

By joining E015, members acting as Service Providers, Application Providers and/or Glossary Providers can immediately take advantage of the following benefits:

- Enrich existing end-user applications – Web sites, mobile apps, information kiosks etc. – with valuable contents and functionalities provided by the E015 services published in the ecosystem.
- Significantly reduce development time and costs of new integrated end-user applications.
- Have their contents and functionalities widely conveyed by the end-user applications built by other members of the ecosystem.
- Be listed in the participant registry publicly available on the E015 Web portal, i.e., become visible inside and outside the ecosystem, in particular to players potentially interested in the development of new integrated applications.
- Qualify and improve corporate communication thanks to the E015 logo and the ecosystem continuous dissemination activities.

3.5 Some Scenarios and Examples

Several innovative end-user applications have been built using the APIs shared in the E015 Digital Ecosystem. These applications

relate to interaction scenarios covering different sectors and domains, thus representing a set of reference guidelines to establish new collaboration initiatives between industry and academia. Some examples follow.

- *E015 in a Government-to-Citizens scenario*. The Regional Government of Lombardy built a Web application named "L15" [9]. It provides users with information about tourism and transportation. This Web application is built according to the E015 coopetitive paradigm: parts of its contents are retrieved by leveraging third-party APIs shared on the E015 Digital Ecosystem, such as real-time transportation data provided by municipalities and events provided by cultural associations. Moreover, the contents shown inside the Web application and directly owned by the Regional Government of Lombardy (e.g., cultural heritage, accommodation) are in turn shared and made available to other E015 members through APIs.

  Figure 3 presents a screenshot highlighting how application mashup has been implemented in "L15". In particular, each tile of the user interface shown by "L15" provides real-time contents retrieved from different services published in E015.

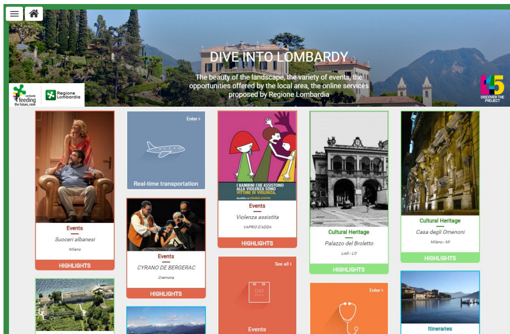


Figure 3. Screenshot of the L15 application

- *E015 in a Government-to-Government scenario*. In order to ensure an effective monitoring of safety and security during Expo Milano 2015, the Regional Government of Lombardy built an integrated real-time dashboard by using information retrieved from third-party APIs. These APIs were partly published in the E015 Digital Ecosystem, and partly shared by different departments belonging to the Regional Government of Lombardy, thus replicating within that public authority the E015 reference model.

- *E015 in a Business-to-Business scenario*. One of the leading worldwide companies in printing solutions proposed an innovative application based on the E015 Digital Ecosystem, "ExPOSition". Restaurant printers were integrated with an API returning events taking place in Milan during the Universal Exposition, collected by the Municipality of Milan and the Chamber of Commerce of Milan into a unique calendar named "Expo in città". In this way, restaurant receipts given to customers could be enriched with information about events taking place near that restaurant in the same day and time window, thus unlocking additional value from events published as APIs in the E015 Digital Ecosystem.

- *E015 in a scenario involving universities, enterprises and startups*. In the context of a EIT Digital [5] activity, an international team including universities, enterprises and startups, exploited the Universal Exposition of Milan as an opportunity to test advanced semantic technologies. The international team built a comprehensive knowledge base, the "3cixty KB", that contains descriptions of events, places, transportation facilities and social activities, using APIs shared on the E015 Digital Ecosystem by local companies and public authorities. The team published a multi-device application named "ExplorMI 360" [6]. The project was awarded as winner of the Semantic Web Challenge at the 14th Semantic Web Conference ISWC 2015 [11].

  This is a significant example of cooperation between researchers and practitioner through E015.

  Figure 4 shows a screenshot of the "ExplorMI 360" application, illustrating how information coming from different APIs is coherently presented to the end-users by leveraging data reconciliation techniques and a knowledge base developed by the 3cixty initiative.

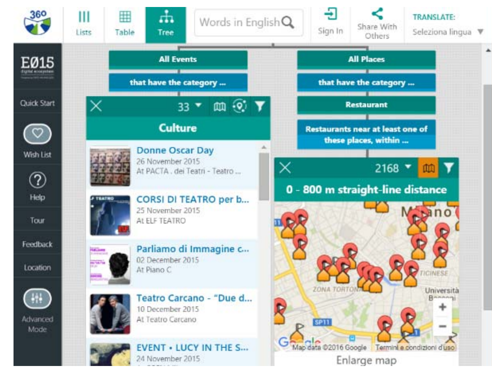


Figure 4. Screenshot of the ExplorMI 360 Web application

4. E015 COLLABORATION MECHANISMS BETWEEN RESEARCHERS AND PRACTITIONERS

The E015 vision illustrated above is particularly effective as for enabling collaboration between academia and industry. In fact, the E015 reference model can constitute the foundation of various types of value-added interaction scenarios between researchers and practitioners, e.g.:

- Researchers can easily have access to valuable data provided by industrial actors as APIs published in the ecosystem. This opportunity enables both the possibility of testing algorithms and research results on real data and, at the same time, the development of innovative prototypal applications, exploiting the results of research into effective case studies.

- Researchers can share their results and achievements by publishing APIs that can be accessed by several ecosystem participants. Researchers can also target such APIs to particular sets of potential users (e.g., for specific piloting or experimentation purposes), including industry players. In turn, industries can more easily support the exploitation of research results thanks to the fact that they are made available through APIs, by adopting standard technologies, as well as documented in a straightforward description format that can be easily grasped by both IT and business stakeholders.

- Thanks to the collaboration mechanisms of the ecosystem, industries can share with academia their major current requirements, regarding, e.g., new technologies or functionalities that still do not exist or that are not mature

enough yet. In turn, academia can more easily identify and recognize the main needs and requirements expressed by both industries and the market, and then address them by focusing on the most relevant and promising topics and trends.

- Researchers can contribute to standardization also by proposing new ecosystem glossaries for representing and exchanging information as well as for modelling APIs, possibly targeting specific application domains.

The main advantages deriving from a better, closer and easier collaboration between industry and academia through the E015 Digital Ecosystem approach are:

- More integrated applications for the end-users, benefitting from both novel research solutions and sound industry development approaches.
- More effective exploitation of research results performed by industry, thanks to the API-based collaboration mechanisms fostered by the ecosystem.
- More focused reuse of functionalities, data and know-how across all of the participants of the ecosystem, thus unlocking additional value from shared assets.
- Faster standardization and technological convergence processes, thanks to common guidelines and glossaries enforced by a Technical Management Board.
- Higher level of technological maturity achieved also by small players (both ICT solutions providers and consumers) supported by the technical guidelines and governance mechanisms of the ecosystem.
- Broader involvement of ecosystem participants and stronger commitment on the realization of innovative solutions, thanks to onboarding initiatives targeting both business and technical stakeholders.

Cooperation between researchers and practitioners has been crucial for the success of E015. In fact, on the one hand researchers and scientific committees have provided the necessary insights about ongoing technological trends and future perspectives, so that it has been possible to push E015 technical guidelines to the boundaries of available technologies according to a coherent and comprehensive vision. On the other hand, by means of an effectual and win-win give-and-take approach, practitioners have integrated this technical vision with business requirements, knowledge about industrial tools and techniques for the development of APIs and solutions, and real use cases for the adoption of this new approach.

5. CONCLUSIONS

In this paper we presented the E015 Digital Ecosystem, the environment of APIs and end-user applications developed for Expo Milano 2015, still operating and widely used.

E015 adopts the API Economy as a reference collaboration paradigm, because of its intrinsic potential in fostering innovation going beyond the traditional development of vertical solutions. In fact, even if APIs are commonly adopted as an ICT technology, the adoption of APIs as a strategical business asset is currently still limited by a lack of awareness of the additional business value they can unlock.

In order to conquer this problem, an effective API Economy initiative should investigate what is really needed at application level, by addressing key dimensions such as an overarching architectural model based on a sound interoperability framework, shared technical standards and guidelines supported by specific organizational processes, and proper onboarding initiatives to make actors (e.g., players of both the private and public sector) conscious of the innovative business models enabled by APIs.

The E015 Digital Ecosystem, nowadays recognized as a best practice and a successful reference initiative in the field of the API Economy, implements such dimensions in a digital lightweight interoperability environment based on the Service-Oriented Architecture pattern supported by collaboration rules, policies and processes, and both a Technical and a Governance Board.

The E015 vision proves particularly effective as for enabling a synergetic collaboration between academia and industry: the continuous give-and-take interaction between researchers and practitioners enabled by the ecosystem can trigger beneficial effects on innovation, providing end-users with more and more value-added solutions benefitting from both innovative research outcomes and industry proven and sustainable development approaches.

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